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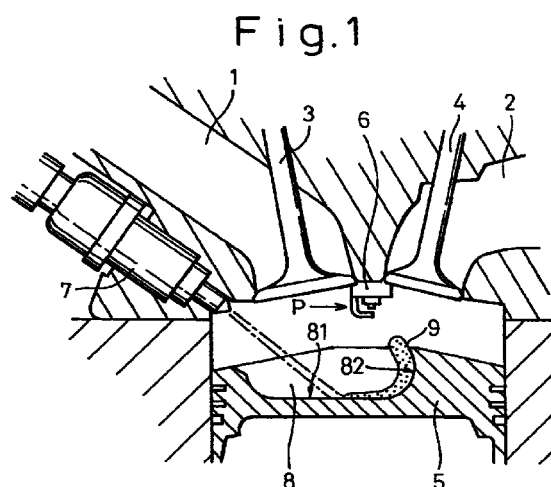
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(54) **Direct cylinder injection-type spark ignition internal combustion engine**

(57) A direct cylinder injection-type spark ignition internal combustion engine is disclosed. The engine comprises a spark plug (6), a cavity (8) formed in the top surface of a piston (5), and a fuel injection valve (7) for injecting fuel into the cavity in nearly the shape of a fan having a relatively small thickness. When the fuel injected in nearly the shape of a fan from the fuel injection valve is considered by being divided into a plurality of fuel segments in a radial direction, a side wall (82) of the cavity has a first fuel deflection passage (82a) and a second fuel deflection passage (82b) for so deflecting at least two of the plurality of fuel segments as to pass near the spark plug. The side wall of the cavity is at least partly provided with a return portion (83) that protrudes toward the inside of the cavity. The first fuel deflection passage is not provided with the return portion (83) or is provided with the return portion having a short protrusion, and the second fuel deflection passage is provided with the return portion (83) having a long protrusion.





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EUROPEAN SEARCH REPORT

Application Number
EP 99 11 3157

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 10, 31 October 1997 (1997-10-31) & JP 09 158736 A (TOYOTA CENTRAL RES & DEV LAB INC), 17 June 1997 (1997-06-17) * abstract *	1	F02B23/10
A	--- PATENT ABSTRACTS OF JAPAN vol. 1997, no. 02, 28 February 1997 (1997-02-28) & JP 08 260986 A (TOYOTA MOTOR CORP), 8 October 1996 (1996-10-08) * abstract *	1-7	
A	--- EP 0 496 029 A (TOYOTA MOTOR CO LTD) 29 July 1992 (1992-07-29) * figures *	1-7	
A	--- EP 0 694 682 A (TOYOTA MOTOR CO LTD) 31 January 1996 (1996-01-31) * figures *	1-7	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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-The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 October 1999	Examiner ALCONCHEL, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-7



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**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 99 11 3157

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-7

A direct cylinder injection type spark ignition internal combustion engine with a cavity in the piston wherein a particular return portion and/or arcuate shape is provided.

2. Claims: 8-10

A direct cylinder injection type spark ignition internal combustion engine with a cavity in the piston wherein different angles of collision of the fuel into the cavity are provided.

3. Claims: 11-13

A direct cylinder injection type spark ignition internal combustion engine with a cavity in the piston wherein said cavity has a side wall with different depths.

4. Claim : 14

A direct cylinder injection type spark ignition internal combustion engine with a cavity in the piston wherein the bottom wall of said cavity has a plurality of fuel leading passages with different lengths thereof.

5. Claims: 15,16

A direct cylinder injection type spark ignition internal combustion engine with a cavity having concave or convex resisting portions.

6. Claims: 17-21

A direct cylinder injection type spark ignition internal combustion engine with a cavity in the piston having guide protuberances to form fuel passages.

7. Claims: 22-23

A direct cylinder injection type spark ignition internal combustion engine with a cavity wherein the bottom wall is inclined.

8. Claims: 24-27



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**LACK OF UNITY OF INVENTION
SHEET B**

Application Number
EP 99 11 3157

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

A direct cylinder injection type spark ignition internal combustion engine with a cavity which has been turned by a predetermined angle about the axis in the vertical direction.

9. Claim : 28

A direct cylinder injection type spark ignition internal combustion engine with a cavity in the piston, means to form a swirl and having a protruding portion formed on the top surface of the piston.

10. Claim : 29

A direct cylinder injection type spark ignition internal combustion engine with a cavity and a squish area formed on the top surface of the piston.

11. Claim : 30

A direct cylinder injection type spark ignition internal combustion engine having a cavity in the piston with stepped portions and a squish area formed on the top surface of the piston.

12. Claims: 31-33

A direct cylinder injection type spark ignition internal combustion engine wherein the fuel injected is decreased in the last stage of fuel injection.

13. Claim : 34

A direct cylinder injection type spark ignition internal combustion engine wherein the crank shaft center is deviated from the center axis of the piston.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 11 3157

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-10-1999

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